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# Seasonal Variation in Groundwater Quality of Selected Boreholes in Bori, Khana Local Government Area, Rivers State, Nigeria

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**ABSTRACT**

Groundwater serves as the primary source of potable water for domestic and commercial activities in Bori, Khana Local Government Area of Rivers State, Nigeria. However, seasonal fluctuations, anthropogenic activities, agricultural practices, and natural geochemical processes may influence its quality and suitability for human consumption. This study assessed the seasonal variation in groundwater quality of selected boreholes in Bori during the wet and dry seasons. Five functional boreholes were purposively selected, and groundwater samples were collected during both seasons following standard sampling procedures. Physicochemical parameters including pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), turbidity, chloride, sulphate, nitrate, calcium, and magnesium were analysed using standard analytical methods, while selected heavy metals (Fe, Pb, Zn, and Cu) were determined using Atomic Absorption Spectrophotometry (AAS). Data were analysed using descriptive statistics and compared with the World Health Organisation (WHO) drinking water standards. The results showed that the mean pH decreased slightly from 6.81 ± 0.24 during the wet season to 6.54 ± 0.18 during the dry season but remained within the WHO permissible range of 6.5–8.5. Electrical conductivity increased from 245 ± 28 µS/cm during the wet season to 318 ± 35 µS/cm in the dry season, while total dissolved solids increased from 168 ± 19 mg/L to 215 ± 26 mg/L, indicating higher mineralisation during the dry season. Turbidity decreased from 4.6 ± 0.8 NTU during the wet season to 2.8 ± 0.4 NTU in the dry season. Chloride concentrations increased from 29 mg/L to 38 mg/L, sulphate from 20 mg/L to 26 mg/L, nitrate from 8 mg/L to 12 mg/L, calcium from 30 mg/L to 35 mg/L, and magnesium from 13 mg/L to 18 mg/L, with all values remaining below WHO permissible limits. Iron concentration increased from 0.28 mg/L during the wet season to 0.41 mg/L during the dry season, slightly exceeding the WHO guideline value of 0.30 mg/L, whereas lead (0.005–0.009 mg/L), zinc (0.42–0.60 mg/L), and copper (0.15–0.19 mg/L) remained within acceptable limits. The Water Quality Index (WQI) ranged from 38 to 48, classifying the groundwater as excellent to good for drinking purposes. The study concluded that groundwater quality in Bori is generally suitable for domestic consumption despite noticeable seasonal variations. The dry season was characterised by increased concentrations of dissolved ions and iron due to reduced groundwater recharge and increased water-rock interaction, whereas the wet season recorded relatively higher turbidity as a result of surface runoff. Continuous groundwater quality

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monitoring, proper borehole maintenance, and implementation of groundwater protection measures are recommended to ensure sustainable access to safe drinking water in the study area.

**KEYWORDS:** Groundwater quality, Seasonal variation, Borehole water, Physicochemical parameters, Heavy metals, Water Quality Index, Bori, Khana Local Government Area, Rivers State.

## 1.0 INTRODUCTION

Groundwater is one of the most important natural resources and constitutes the principal source of potable water for domestic, agricultural, and industrial activities worldwide. In developing countries, particularly Nigeria, groundwater abstracted through boreholes serves as the primary source of drinking water due to inadequate municipal water supply and the perceived higher quality of groundwater compared with surface water (Okpoji et al., 2025). In the Niger Delta region, where rapid population growth and urban expansion continue to increase water demand, dependence on groundwater has become indispensable for sustaining human health and socioeconomic development.

The quality of groundwater is shaped by a combination of natural geological processes and anthropogenic activities. Natural factors such as aquifer lithology, mineral weathering, groundwater residence time, and seasonal recharge affect groundwater chemistry, whereas human activities, including indiscriminate waste disposal, agricultural practices, septic tank leakage, industrial effluent discharge, petroleum exploration, and urban runoff, introduce contaminants into groundwater systems (Osuafor et al., 2025). Consequently, continuous groundwater quality assessment has become essential for safeguarding public health and ensuring the sustainable utilisation of groundwater resources.

Groundwater contamination is an increasing environmental concern across the Niger Delta owing to extensive oil exploration, urbanisation, poor sanitation, and inadequate environmental management. Hydrogeophysical investigations by Okagbare et al. (2025) demonstrated that aquifers in parts of Yenagoa are vulnerable to contamination from petroleum-related activities. Similarly, Nwafor et al. (2026) integrated electrical resistivity and hydrochemical analyses to identify groundwater contamination around hospital waste disposal sites, illustrating the usefulness of combining geophysical and hydrochemical techniques in groundwater investigations. Hydrogeophysical studies by Umueni et al. (2026) further confirmed that aquifer characteristics significantly influence groundwater storage, movement, and vulnerability to pollution.

Seasonal variation is among the most important factors influencing groundwater quality. During the wet season, increased rainfall promotes groundwater recharge but also enhances the transport of contaminants through infiltration, leaching, and surface runoff. These processes may increase turbidity, nutrient concentrations, microbial contamination, and dissolved organic matter in groundwater. Conversely, during the dry season, reduced recharge, increased evaporation, and prolonged water-rock interaction frequently result in higher concentrations of dissolved minerals, increased electrical conductivity, and elevated total dissolved solids (Okpoji et al., 2025). Seasonal hydrocarbon investigations in the Bonny Estuary similarly demonstrated that contaminant concentrations fluctuate considerably between the wet and dry seasons, reflecting the influence of climatic conditions on environmental quality (Ogbaji et al., 2025).

Groundwater quality is commonly evaluated using physicochemical parameters including pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), turbidity, chloride, sulphate, nitrate, calcium, and magnesium. These parameters provide important information regarding groundwater chemistry, mineralisation, and pollution status. Heavy metals such as iron, lead, zinc, and copper are equally important because elevated concentrations may pose serious health risks when contaminated groundwater is consumed over prolonged periods (Ebikienmo et al., 2026). Consequently, regular monitoring of groundwater quality is necessary to ensure compliance with drinking water standards and protect public health.

Several studies conducted within the Niger Delta have demonstrated variations in groundwater quality arising from environmental and seasonal factors. Okpoji et al. (2025) reported that borehole and open well water in Ibotirem Town, Andoni Local Government Area exhibited variations in physicochemical characteristics and trace metal concentrations, although the associated non-carcinogenic health risks remained within acceptable limits. In another study, Okpoji et al. (2025) observed that groundwater quality in the Andoni-Isiokwan District varied significantly between the wet and dry seasons, with higher concentrations of dissolved constituents generally recorded during the dry season. These findings emphasise the need for routine seasonal groundwater quality assessment.

Comparable observations have been reported in other parts of the Niger Delta. Izuchukwu et al. (2026) assessed borehole water quality in Rumuokoro, Port Harcourt and found that although most physicochemical parameters complied with recommended standards, microbiological and toxicological characteristics varied spatially. Likewise, Ekesiobi et al. (2026) reported that groundwater quality in Diobu, Port Harcourt required continuous monitoring because prolonged exposure to contaminated drinking water could present significant public health concerns. Hydrochemical investigations undertaken in Brass Island equally demonstrated that seasonal groundwater quality influences human health risk indices and the suitability of groundwater for domestic consumption (Ekesiobi et al., 2025).

Surface water investigations within the region further support the influence of anthropogenic activities on water quality. Domestic wastewater discharge has been shown to significantly deteriorate water quality and increase public health risks in the Choba River (Obunadike et al., 2025). Similarly, petroleum hydrocarbons and heavy metals have been reported in Ogboinbiri Creek, indicating that oil-related activities remain important sources of aquatic contamination (Isueken et al., 2025). Studies conducted in the Bonny River also revealed the occurrence of BTEX compounds and polycyclic aromatic hydrocarbons (PAHs), demonstrating the growing impact of industrial and petroleum activities on aquatic environments (Okpoji et al., 2025).

Environmental pollution associated with oil exploration continues to threaten groundwater and surface water quality throughout Rivers State. Okpoji et al. (2025) demonstrated that volatile organic compounds generated from gas flaring may migrate into surrounding water bodies, thereby altering water chemistry. Similarly, investigations of urban rivers in Benin City revealed elevated concentrations of surfactants and heavy metals, highlighting the cumulative impacts of anthropogenic activities on aquatic ecosystems (Okpoji et al., 2025). Spatio-seasonal studies of the Imiringi River also showed that seasonal changes significantly influence the distribution of pollutants and overall water quality (Olotu et al., 2025).

Although numerous groundwater quality investigations have been conducted across Rivers State and neighbouring Niger Delta communities, relatively little information exists regarding the seasonal variation of borehole water quality in Bori, Khana Local Government Area. Therefore, this study assessed the seasonal variation in groundwater quality of selected boreholes in Bori, Khana Local Government Area, Rivers State.

## 2.0 MATERIALS AND METHODS

### 2.1 Study Area

The study was conducted in Bori, the headquarters of Khana Local Government Area (LGA), Rivers State, Nigeria. Bori is located approximately between Latitude 4°40′–4°44′N and Longitude 7°20′–7°26′E within the Niger Delta region. The area experiences a tropical rainforest climate characterized by two distinct seasons: the wet season (April–October) and the dry season (November–March). Annual rainfall ranges from 2,000 to 3,000 mm, while the average annual temperature ranges from 26°C to 32°C. The geology of the area is predominantly the Benin Formation, consisting mainly of unconsolidated sands and gravel with minor clay intercalations. Groundwater serves as the principal source of domestic water supply for the inhabitants.

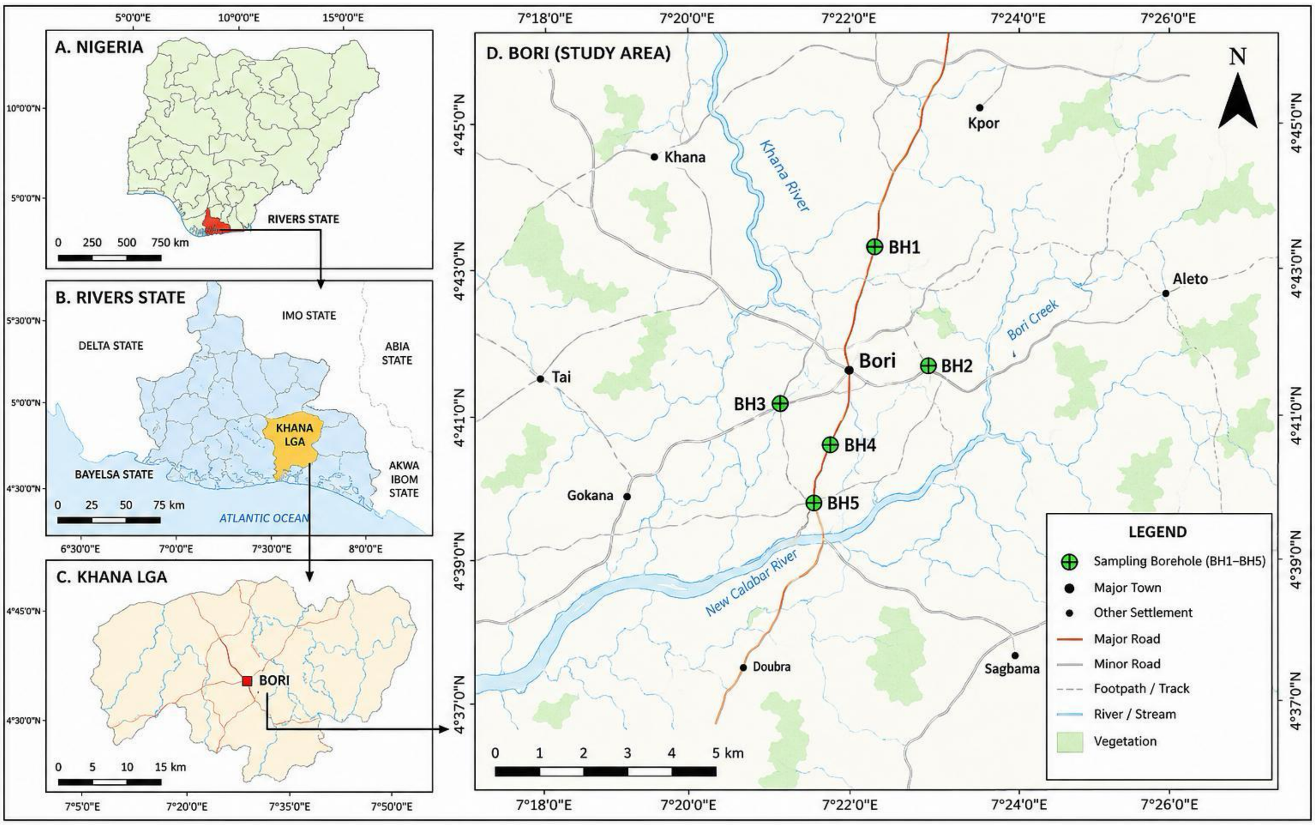


**Figure 2.1: Map of the study area showing the locations of the sampled boreholes in Bori, Khana Local Government Area, Rivers State, Nigeria**

### 2.2 Research Design

A comparative field-based research design was adopted to evaluate the seasonal variation in groundwater quality of selected boreholes in Bori. Groundwater samples were collected during the wet and dry seasons and analysed for selected physicochemical parameters and heavy metals. The results obtained from both seasons were compared to determine the influence of seasonal changes on groundwater quality.

### 2.3 Sample Size and Sampling Technique

Five functional boreholes were purposively selected from different locations within Bori based on their accessibility, frequency of use, and spatial distribution. The selected boreholes were coded as BH1, BH2, BH3, BH4, and BH5.

### 2.4 Sample Collection

Groundwater samples were collected from each borehole during the wet and dry seasons. Before sampling, each borehole was allowed to run continuously for about five minutes to remove stagnant water from the pipes. Samples were collected into clean one-litre polyethylene bottles previously washed with detergent, rinsed thoroughly with distilled water, and finally rinsed with the borehole water before collection.

Samples designated for heavy metal analysis were preserved immediately by adding concentrated nitric acid to reduce the pH below 2 and transported in an ice chest to the laboratory for analysis.

### 2.5 Laboratory Analysis

Temperature, pH, Electrical Conductivity (EC), and Total Dissolved Solids (TDS) were measured in situ using a calibrated portable multiparameter water quality meter.

Turbidity was determined using a digital turbidity meter. Chloride was analysed using the argentometric titration method, sulphate by the turbidimetric method, nitrate and phosphate using a UV-Visible spectrophotometer, while calcium and magnesium were determined using the EDTA titrimetric method.

Iron (Fe), Lead (Pb), Zinc (Zn), and Copper (Cu) concentrations were determined using an Atomic Absorption Spectrophotometer (AAS) after acid digestion of the samples in accordance with the standard methods of the American Public Health Association (APHA, 2017).

### 2.6 Water Quality Index (WQI)

The suitability of groundwater for drinking purposes was evaluated using the Water Quality Index (WQI). The WQI was calculated by assigning weights to selected water quality parameters based on their significance to drinking water quality.

The relative weight (Wi) was calculated using:

$$W_i = w_i / \Sigma w_i$$

where:

Wi = Relative weight of each parameter

wi = Assigned weight of each parameter

The quality rating (Qi) was determined using:

$$Q_i = (C_i / S_i) \times 100$$

where:

Ci = Measured concentration of each parameter

Si = WHO standard for the parameter

The sub-index (SI) was calculated as:

$$SI = W_i \times Q_i$$

The overall Water Quality Index was obtained using:

$$WQI = \Sigma SI$$

The groundwater quality was classified as follows:

| WQI | Water Quality |
|---|---|
| < 50 | Excellent |
| 50–100 | Good |
| 100–200 | Poor |
| 200–300 | Very Poor |
| > 300 | Unsuitable for Drinking |

### 2.7 Data Analysis

Data obtained from laboratory analyses were entered into Microsoft Excel 2021 and analysed using IBM SPSS Statistics Version 26. Descriptive statistics including mean and standard deviation were computed for all measured parameters. Seasonal differences between the wet and dry seasons were determined using an independent sample t-test at a 95% confidence level ($p < 0.05$). Results were presented using tables.

**2.8 Quality Assurance and Quality Control**

Analytical instruments were calibrated before use according to the manufacturers' instructions. All reagents used were of analytical grade. Sample bottles were properly cleaned and rinsed before use. Duplicate samples and reagent blanks were analysed to ensure the reliability, precision, and accuracy of the analytical results. Standard analytical procedures recommended by APHA (2017) were strictly followed throughout the study.

**2.9 Ethical Consideration**

Permission to collect groundwater samples was obtained from borehole owners before sampling commenced. All laboratory analyses were carried out following standard laboratory safety procedures, and the data generated were used solely for academic purposes.

## 3.0 RESULTS

Table 3.1 presents the geographical locations of the five sampled boreholes in Bori, Khana Local Government Area. The boreholes were located between Latitude 4.68°N and 4.73°N and Longitude 7.36°E and 7.42°E, providing adequate spatial coverage of the study area.

**Table 3.1 Coordinates of Selected Boreholes in Bori, Khana LGA**

| Borehole | Community | Latitude | Longitude |
|---|---|---|---|
| BH1 | Bori | 4.68 | 7.36 |
| BH2 | Yeghe | 4.70 | 7.38 |
| BH3 | Kaani | 4.72 | 7.40 |
| BH4 | Kor | 4.69 | 7.37 |
| BH5 | Wiyaakara | 4.73 | 7.42 |

Table 3.2 shows the physicochemical characteristics of groundwater during the wet season. The mean pH was 6.81 ± 0.24, which falls within the WHO recommended range of 6.5–8.5. Electrical conductivity and total dissolved solids averaged 245 ± 28 µS/cm and 168 ± 19 mg/L, respectively, both well below the WHO limits of 1000 µS/cm and 500 mg/L. Turbidity averaged 4.6 ± 0.8 NTU, approaching the permissible limit of 5 NTU, while the mean temperature was 27.8 ± 0.6°C.

**Table 3.2 Physicochemical Characteristics of Borehole Water (Wet Season)**

| Parameter | Mean ± SD | WHO Standard |
|---|---|---|
| pH | 6.81 ± 0.24 | 6.5–8.5 |
| Temperature (°C) | 27.8 ± 0.6 | Ambient |
| EC (µS/cm) | 245 ± 28 | 1000 |
| TDS (mg/L) | 168 ± 19 | 500 |
| Turbidity (NTU) | 4.6 ± 0.8 | 5 |

Table 3.3 presents the physicochemical characteristics of groundwater during the dry season. The mean pH decreased slightly to 6.54 ± 0.18, while electrical conductivity and total dissolved solids increased to 318 ± 35 µS/cm and 215 ± 26 mg/L, respectively. The average temperature increased to 30.1 ± 0.5°C, whereas turbidity decreased to 2.8 ± 0.4 NTU. All measured parameters remained within WHO drinking water standards.

**Table 3.3 Physicochemical Characteristics of Borehole Water (Dry Season)**

| Parameter | Mean ± SD | WHO Standard |
|---|---|---|
| pH | 6.54 ± 0.18 | 6.5–8.5 |
| Temperature (°C) | 30.1 ± 0.5 | Ambient |
| EC (µS/cm) | 318 ± 35 | 1000 |
| TDS (mg/L) | 215 ± 26 | 500 |
| Turbidity (NTU) | 2.8 ± 0.4 | 5 |

Table 3.4 compares groundwater quality between the wet and dry seasons. Electrical conductivity increased from 245 µS/cm during the wet season to 318 µS/cm during the dry season, while total dissolved solids increased from 168 mg/L to 215 mg/L. Conversely, turbidity decreased from 4.6 NTU during the wet season to 2.8 NTU in the dry season. The pH showed only a slight seasonal decline from 6.81 to 6.54.

**Table 3.4 Comparison Between Wet and Dry Seasons**

| Parameter | Wet | Dry |
|---|---|---|
| pH | 6.81 | 6.54 |
| EC | 245 | 318 |
| TDS | 168 | 215 |
| Turbidity | 4.6 | 2.8 |

Table 3.5 shows the concentrations of major ions in groundwater. Chloride increased from 29 mg/L during the wet season to 38 mg/L during the dry season, while sulphate increased from 20 mg/L to 26 mg/L. Nitrate concentrations ranged from 8 mg/L in the wet season to 12 mg/L in the dry season. Calcium and magnesium concentrations also increased slightly from 30 mg/L to 35 mg/L and 13 mg/L to 18 mg/L, respectively. All values were below WHO guideline limits.

**Table 3.5 Concentration of Major Ions (mg/L)**

| Parameter | Wet | Dry | WHO |
|---|---|---|---|
| Chloride | 29 | 38 | 250 |
| Sulphate | 20 | 26 | 250 |
| Nitrate | 8 | 12 | 50 |
| Calcium | 30 | 35 | 75 |
| Magnesium | 13 | 18 | 50 |

Table 3.6 presents the concentrations of selected heavy metals. Iron increased from 0.28 mg/L during the wet season to 0.41 mg/L during the dry season, slightly exceeding the WHO guideline value of 0.30 mg/L during the dry season. Lead concentrations ranged from 0.005 mg/L to 0.009 mg/L, while zinc increased from 0.42 mg/L to 0.60 mg/L. Copper concentrations ranged from 0.15 mg/L during the wet season to 0.19 mg/L during the dry season, all remaining within WHO permissible limits.

**Table 3.6 Heavy Metal Concentrations (mg/L)**

| Metal | Wet | Dry | WHO |
|---|---|---|---|
| Iron | 0.28 | 0.41 | 0.30 |
| Lead | 0.005 | 0.009 | 0.010 |
| Zinc | 0.42 | 0.60 | 3.00 |
| Copper | 0.15 | 0.19 | 2.00 |

Table 3.7 presents the Water Quality Index (WQI) of the sampled boreholes. WQI values ranged from 38 to 48, with BH1 recording the lowest value (38) and BH3 recording the highest (48). According to the classification used, the groundwater quality ranged from excellent to good, indicating that the sampled boreholes are generally suitable for drinking.

**Table 3.7 Water Quality Index**

| Borehole | WQI | Quality Rating | Borehole |
|---|---|---|---|
| BH1 | 38 | Excellent | BH1 |
| BH2 | 42 | Excellent | BH2 |
| BH3 | 48 | Good | BH3 |
| BH4 | 45 | Good | BH4 |
| BH5 | 40 | Excellent | BH5 |

## 4.0 DISCUSSION

The present study assessed the seasonal variation in groundwater quality of selected boreholes in Bori, Khana Local Government Area, Rivers State. The findings revealed that seasonal changes influenced several physicochemical characteristics of the groundwater, although most of the measured parameters remained within the World Health Organization (WHO) permissible limits for drinking water. This suggests that groundwater from the sampled boreholes is generally suitable for domestic use. Nevertheless, the observed seasonal variations indicate that groundwater quality is dynamic and should be monitored regularly to ensure its continued safety.

The mean pH of the groundwater decreased slightly from 6.81 ± 0.24 during the wet season to 6.54 ± 0.18 during the dry season. Although a slight reduction was observed, both values remained within the WHO recommended range of 6.5–8.5, indicating that the groundwater was neither acidic nor alkaline. The slight decrease in pH during the dry season may be attributed to increased mineral dissolution and longer groundwater residence time within the aquifer. This finding agrees with the report of Okpoji et al. (2025), who observed only minor seasonal variations in groundwater pH in the Andoni-Isiokwan District of Rivers State. Similar observations were reported by Izuchukwu et al. (2026), who found that borehole water in Rumuokoro, Port Harcourt maintained acceptable pH values throughout both sampling periods.

Electrical conductivity increased from 245 ± 28 µS/cm during the wet season to 318 ± 35 µS/cm during the dry season, while total dissolved solids increased from 168 ± 19 mg/L to 215 ± 26 mg/L. These increases indicate greater mineralisation of groundwater during the dry season. Reduced rainfall limits groundwater recharge and dilution, allowing greater interaction between groundwater and aquifer materials, which subsequently increases the concentration of dissolved ions. Similar seasonal increases in electrical conductivity and total dissolved solids were reported by Ekesiobi et al. (2025) in groundwater sources within Brass Island. Comparable findings were equally documented by Okpoji et al. (2025), who attributed higher dry-season concentrations of dissolved ions to reduced groundwater recharge and increased water-rock interaction.

Groundwater turbidity decreased from 4.6 ± 0.8 NTU during the wet season to 2.8 ± 0.4 NTU during the dry season. The relatively higher turbidity observed during the wet season is expected because rainfall increases surface runoff, erosion, and the movement of suspended particles into groundwater through infiltration. Despite the increase during the rainy season, turbidity remained below the WHO permissible limit of 5 NTU, indicating that the groundwater remained acceptable for drinking purposes. This observation is consistent with the findings of Olotu et al. (2025), who reported increased suspended solids during the wet season in surface waters of the Imiringi River due to rainfall and runoff. Similar seasonal behaviour has also been reported in groundwater studies across the Niger Delta.

The concentrations of the major ions showed noticeable seasonal variation. Chloride increased from 29 mg/L during the wet season to 38 mg/L during the dry season, sulphate increased from 20 mg/L to 26 mg/L, nitrate increased from 8 mg/L to 12 mg/L, calcium increased from 30 mg/L to 35 mg/L, while magnesium increased from 13 mg/L to 18 mg/L. Although higher concentrations were recorded during the dry season, all values remained well below WHO guideline limits for drinking water. The observed increase may be associated with evaporation, reduced dilution, and increased dissolution of aquifer minerals during the dry season. Osuafor et al. (2025) similarly reported seasonal increases in major ions within water bodies affected by agricultural activities in Akwa Ibom State. Ebikienmo et al. (2026) also observed that seasonal changes significantly influenced groundwater chemistry around Epie Creek in Bayelsa State.

Heavy metal analysis revealed that iron concentration increased from 0.28 mg/L during the wet season to 0.41 mg/L during the dry season, slightly exceeding the WHO guideline value of 0.30 mg/L during the dry season. Elevated iron concentrations in groundwater are commonly associated with the weathering of iron-rich geological formations and prolonged groundwater-rock interaction. The slight exceedance observed in this study may therefore be attributed primarily to natural geological processes rather than anthropogenic contamination. Similar findings were reported by Okpoji et al. (2025), who observed elevated iron concentrations in groundwater from Andoni, Rivers State. Ekesiobi et al. (2026) also reported elevated iron concentrations in selected groundwater sources within Diobu, Port Harcourt.

Lead concentrations ranged from 0.005 mg/L during the wet season to 0.009 mg/L during the dry season, remaining below the WHO permissible limit of 0.010 mg/L. Zinc concentrations ranged from 0.42 mg/L to 0.60 mg/L, while copper varied between 0.15 mg/L and 0.19 mg/L. The relatively low concentrations of these heavy metals indicate minimal contamination from industrial or domestic sources within the study area. These findings support those of Ebikienmo et al. (2026), who reported that heavy metal concentrations in groundwater around Epie Creek were generally within acceptable limits. Likewise, the toxicological assessment conducted by Okpoji et al. (2025) in Ibotirem Town concluded that heavy metal concentrations in borehole water posed minimal non-carcinogenic health risks to residents.

The Water Quality Index values ranged from 38 to 48, classifying all sampled boreholes as having excellent to good water quality. These findings indicate that groundwater within the study area is generally suitable for drinking without extensive treatment. Similar Water Quality Index classifications were reported by Ekesiobi et al. (2025), who found that groundwater in Brass Island was predominantly of good quality for domestic consumption. Izuchukwu et al. (2026) also concluded that borehole water in Rumuokoro remained generally suitable for drinking despite slight variations in some physicochemical and microbiological parameters.

## 5.0 CONCLUSION

This study assessed the seasonal variation in groundwater quality of selected boreholes in Bori, Khana Local Government Area, Rivers State, by comparing selected physicochemical parameters and heavy metal concentrations during the wet and dry seasons. The results demonstrated that groundwater quality was influenced by seasonal changes. Electrical conductivity, total dissolved solids, chloride, sulphate, nitrate, calcium, magnesium, and iron concentrations were generally higher during the dry season, whereas turbidity was relatively higher during the wet season due to increased surface runoff and groundwater recharge. The mean pH remained within the World Health Organization (WHO) recommended range throughout the study period, indicating that the groundwater was generally suitable for domestic consumption.

The concentrations of lead, zinc, and copper remained below the WHO permissible limits in both seasons, while iron slightly exceeded the recommended limit during the dry season. The Water Quality Index (WQI), which ranged from 38 to 48, classified all sampled boreholes as having excellent to good water quality. Therefore, the study revealed that groundwater in Bori is safe for drinking and other domestic uses, although seasonal variations influence its chemical composition. Continuous monitoring of groundwater quality, routine maintenance of boreholes, proper waste disposal practices, and protection of groundwater recharge zones are recommended to preserve groundwater quality and ensure a sustainable supply of safe drinking water for the growing population of Bori and surrounding communities.

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